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Dynamic benthic silicon cycling in Southwest Greenland fjords revealed by stable isotopes

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Driven by atmospheric warming, the Greenland Ice Sheet has been experiencing accelerated melting in recent years, which has strongly influenced surrounding fjord and coastal systems. This fresh-water runoff, together with shallow fjord sediments, is an important source of key nutrients into downstream ecosystems. Silicon (Si) is one such nutrient, which is critical for the growth of diatoms, an important group of algae that are essential for maintaining ecosystem health, the ocean biological pump, and atmospheric carbon fixation. Benthic fluxes of dissolved Si (DSi) from sediments into deeper oceanic waters are regulated by processes such as the dissolution of terrigenous Si minerals, labile amorphous silica (ASi), and the precipitation of authigenic Si phases. These early diagenetic processes also have a specific effect on Si isotopic composition in porewaters. However, our understanding of the dynamic mechanism of benthic Si cycle is currently limited, especially in fjord system, which makes it difficult to predict how the Greenland margin ecosystems will be affected by future climate change.

Here we measure the concentration and stable isotopic composition of pore-water DSi, core-top water DSi, and sediment ASi of sediment cores collected from two different fjords along the southwest Greenland. We couple these measurements with core incubation experiments and mass balance modelling to quantitatively estimate the contribution of the different early diagenetic processes of Si to the benthic flux of this nutrient. Our results show a significant increase in pore water δ^{30}Si from the overlying core-top water values. This increase suggests that processes which preferentially incorporate the light ^{28}Si isotope, such as precipitation of authigenic Si phases and adsorption of DSi onto iron (oxy-)hydroxides, are active in shallow fjord sediments. Based on our data, benthic Si flux at the fjord sites could be explained by molecular diffusion, ASi dissolution, and pore water advection, of which the advective transport has made up the greatest portion. Our study highlights the dynamic equilibrium between silica dissolution, precipitation reactions, and the association of silicon with iron redox cycling in high-latitude fjordic sediments.